Int. J. Nonlinear Anal. Appl. 17 (2026) 4, 63–73
ISSN: 2008-6822 (electronic)
http://dx.doi.org/10.22075/ijnaa.2025.37001.5410

Predicting the manipulation of financial statements of Tehran Stock Exchange companies using the Benish model and Bayesian networks

Jaber Awad Mazal[a], Arezoo Aghaei Chadegani[b,*], Mohammad Samir Dehirab Al-Rubai[c], Mohammad Alimoradi[a]

[a]*Department of Accounting, Isfahan (Khorangan) Branch, Islamic Azad University, Isfahan, Iran*

[b]*Department of Accounting, Najafabad Branch, Islamic Azad University, Najafabad, Iran*

[c]*College of Administration and Economics, Department of Accounting, Al-Muthanna University, Samawah, Iraq*

(Communicated by Madjid Eshaghi Gordji)

Abstract

The increase in manipulation of information and financial statements of companies, as well as the occurrence of fraud and restatement of financial statements, which often lead to the distress and bankruptcy of companies, has raised concerns about the quality of information in financial statements. Given the importance of this issue, discovering or predicting the occurrence of these manipulations and the factors affecting them has always been of interest to researchers, analysts, investors, and managers in companies. Therefore, the purpose of this research is to predict the manipulation of financial statements of companies listed on the Tehran Stock Exchange using the Benish model and the Bayesian network model, as well as to compare the performance of these models in predicting the manipulation of financial statements with each other. This research is applied in terms of purpose, quantitative and post-event in terms of data, and descriptive-correlation in terms of analysis. The statistical population of the research was all companies listed on the Tehran Stock Exchange in the period 2018 to 2022, and the samples were selected using the systematic elimination method. The criterion for selecting companies with financial statement manipulation was that the companies had an unqualified audit opinion with a qualified clause subject to distortion in financial data or the existence of tax disputes with the tax authority according to the income tax reserve note and tax file and the conditional clause of the audit report or the existence of significant annual adjustments and restated financial statements. The research data was collected using library and document mining methods and analyzed using EViews software. The results showed that the Benish model, with an accuracy of 84.26% and Bayesian networks, with an accuracy of 90% have the ability to predict financial statement manipulation among companies listed on the Tehran Stock Exchange. Also, according to the research results, the performance of Bayesian networks, which are artificial intelligence models, in predicting financial statement manipulation is better than the performance of the Benish model, which is a linear model.

Keywords: financial statement manipulation, Benish model, Bayesian network model
2020 MSC: 91G15, 62C10

*Corresponding author
Email addresses: jaberawad1370@yahoo.com (Jaber Awad Mazal), arezooaghaie2001@yahoo.com, arezooaghaei@phu.iaun.ac.ir (Arezoo Aghaei Chadegani), dr.mohamdsm@mu.edu.iq, adealalniman@yahoo.com (Mohammad Samir Dehirab Al-Rubai), alimoradi@khuisf.ac.ir (Mohammad Alimoradi)

Received: February 2025 *Accepted:* April 2025

1 Introduction

Capital markets can be efficient when investors, creditors, and other users have confidence in the financial information reported by companies. The increasing rate of financial statement restatements and manipulations by large companies has undermined confidence in the process of preparing financial statements and reports. In recent years, financial scandals have not only harmed investors, creditors, and shareholders but have also caused various judicial, political, and social costs. In addition to its direct impact on company performance, financial reporting with manipulation and fraud has also affected employees, investors, and creditors, reducing public trust and inefficient capital markets [20]. Financial statement manipulations and frauds include fraudulent and inaccurate reporting, misappropriation of assets, and financial corruption. Misreporting includes manipulating profit figures and providing misleading information that causes harm to users, and misuse of assets includes misuse of tangible and intangible assets, and financial corruption includes paying bribes and other financial fraud [22]. Financial statement manipulation may take the form of misrecognition of revenues, overstatement of assets, improper use of off-balance sheet items, and manipulation of liabilities. Also, manipulation or alteration of accounting records, incorrect application of accounting principles and estimates, and omission of material information are other methods of manipulating financial statements.

In recent years, professional associations have provided solutions to prevent and detect financial statement fraud. For example, in 1988, Auditing Standard No. 53 was issued by the Auditing Standards Board, entitled Auditors' Responsibilities for Detecting and Reporting Mistakes and Violations. In 2002, Standard No. 99 was issued to amend the previous standard. In Iran, in 1998, Standard No. 24, entitled Fraud and Mistakes, addressed this issue. In the Iranian Commercial Code, the responsibility for the accuracy of financial statements lies with the company's management, and according to Article 232, the auditor is responsible for reporting any negligence or violation. Therefore, paying attention to the issue of financial statement manipulation, prevention, and detection of violations is an effective factor in the accuracy of financial reporting by the company's management [23]. For this reason, it is very important to identify companies that manipulate their financial statements and information and to anticipate these manipulations. Manipulations and fraud increase the cost of doing business, create public distrust, and cause the system to collapse and companies to perform poorly. It also negatively impacts the honesty, integrity, and trustworthiness of employees and managers who oversee and control the implementation of laws. Companies can manipulate their financial information and statements through revenue management, arbitrary buying and selling, and the use of fraud. However, companies whose financial reserves are in conflict in a financial period or have managed their earnings late resort to fraud to compensate for their shortcomings. Correctly estimating the probability of financial statement manipulation and financial fraud occurrence will increase the ability to detect and prevent them. It will also reduce the heavy costs imposed on society [7].

The literature on financial statement manipulation includes the transfer of wealth from one beneficiary to another, which is based on information asymmetry. Financial statement manipulation may occur within the framework of generally accepted accounting principles or outside the framework of principles. Therefore, financial statement manipulation may occur in the form of managerial actions in the pattern of earnings management or fraud [11]. Companies manipulate financial statements according to methods consistent with accounting principles or other methods. Violation of generally accepted principles is an important example of fraudulent reporting, and earnings management is carried out within the framework of generally accepted principles. Therefore, financial statement manipulations occur using two methods of fraud and earnings management, and these cases have led to company failures in recent years [15]. According to Howe's research [13], companies first manage earnings, and as they increase, fraud occurs in companies. Many studies have been conducted to detect and identify financial statement manipulations and frauds, and various models are used in this field. The Benish model is one of the common models in the field of detecting and predicting financial statement fraud and manipulations, which uses eight accounting variables in its model. According to the Benish model, with a decrease in gross profit margin, an unusual increase in receivables, sales growth, an increase in accruals, and a decrease in asset quality, the probability of earnings manipulation increases [18]. Benish used financial ratios and accruals to predict earnings manipulation. He used three sources to select variables due to the lack of a suitable theory for manipulating financial information and reports [5]. The first source was related to the company's future signs and future situation, and in his opinion, the probability of earnings manipulation would be higher when the future and future situation are weak. The second source was related to cash flows and accruals, and the third source was related to the positive theory of the contract hypothesis. Benish believed that companies that manipulate their financial information do not only use accruals, but that other variables are necessary to determine the manipulation of financial information [21]. Although linear models are used to predict and detect manipulations and fraud in financial statements, artificial intelligence methods were introduced due to the lack of consideration of hidden layers and variables that affect the dependent variable through endogenous variables. Among the methods of artificial intelligence are Bayesian models. Bayesian networks are graphical probability models that represent a set

of random variables for a given problem and the possible relationships between them. The structure of a Bayesian network is represented by a graph in which each variable is represented by a node and arrows indicate the relationships between the variables. The probabilistic part of a Bayesian network is represented by a set of conditional probabilities [24].

The most important feature of a Bayesian network is its ability to encode both qualitative and quantitative information. Bayesian networks do not require complete observational information, which is very important in manipulation prediction studies because fraudulent samples are usually small and do not tend to disseminate their full information. Bayesian networks are dynamic and easily adapt to new data. Compared to other methods, such as neural networks, Bayesian network models are more transparent because they clearly show the relationships between variables through conditional probability diagrams [16]. Various companies, both private and public, all need systems and models to detect financial manipulations and fraud. To detect financial statement manipulations, it is necessary to check the accuracy and integrity of the financial information in the database of each company. These analyses and reviews can help us a lot in discovering models to predict manipulations. Of course, discovering and presenting these models is not an easy task, and basically identifying a manipulation or fraud will be a very small part of a large data warehouse. Therefore, by considering the issues raised, the importance of financial statement manipulations becomes clearer, and the main problem of this research is to be able to present models to predict financial statement manipulations in companies listed on the Tehran Stock Exchange.

This research attempts to detect, identify, and predict financial statement manipulations for selected samples of listed companies using the M-Score Benish model and Bayesian networks. Therefore, the questions raised in this research include the following:

- Is the Benish M-Score model capable of predicting financial statement manipulation in the Tehran Stock Exchange?
- Is the Bayesian Networks model capable of predicting financial statement manipulation in the Tehran Stock Exchange?
- Is the Bayesian Networks model better than the Benish model for predicting financial statement manipulation?

2 Theoretical foundations and research background

2.1 Financial statement manipulation

The Institute of Certified Public Accountants defines financial statement manipulation as "a deception or false statement made by an individual or organization with the knowledge that the misrepresentation will result in an improper benefit to an individual, business entity, or other party." In simpler terms, financial statement manipulation occurs when a company changes the figures and information in its financial statements to make the company's situation appear more profitable than it is, which is what happened with large companies such as Enron and WorldCom. Fraud in corporate financial reports and statements is considered one of the least common types of fraud in the world, but when it occurs, it is one of the costliest types of fraud, leading to huge losses. Most cases of manipulation are accounting figures, in which stock prices, profit figures, financial information, and other valuations are manipulated to make the company appear more profitable and to state that they are in a better position [4].

Financial statement manipulation takes many forms, such as overstating revenue by recording expected future sales, concealing liabilities, inflating net asset values, and misrepresenting related party transactions and other structured finance transactions. Another type of financial statement manipulation is understating revenue in a financial period and treating it as a reserve for future periods with worse performance [6]. The Sarbanes-Oxley Act [1] was enacted by the US Congress to ensure that companies report their financial condition fairly and honestly and to protect the rights of investors and stakeholders. The rules and policies specified in the Sarbanes-Oxley Act are enforced by the Securities and Exchange Commission and focus broadly on the key areas of accounting regulations, corporate responsibility, corporate governance, and increased criminal penalties. The law is not voluntary, meaning that all companies are required to comply with it, and those who fail to comply are subject to penalties, fines, and even prosecution [9].

Recently, in various studies conducted in the field of financial information manipulation, models have been proposed to predict and detect financial statement manipulations. A set of models proposed includes linear models such as the Benish model and artificial intelligence models such as neural networks, genetic algorithms and Bayesian networks [2]. The Beneish model is explained in detail below.

2.2 Benish Model

The Benish M-Score model is as follows:

$$M - score = -4.84 + 0.92DSRI + 0.528GMI + 0.404AQI + 0.892SGI + 0.115DEPI - 0.172SGAI + 4.679TATA–0.327LVGI$$

If the M-score is less than -2.22, it indicates that the company did not manipulate the profit in that period and if this score is more than 2.22, it indicates that the profit was manipulated in the financial statements. DSRI indicates the changes in receivables relative to sales changes. Due to changes in credit policies to increase sales, an increase in the receivables-to-sales index occurs, but an abnormal increase in receivables also causes an overstatement of income. GMI is the gross profit margin index. If the gross profit margin index is greater than 1, it means that the gross profit margin has decreased significantly. A weakening gross profit margin is a negative sign of the company's outlook and increases the possibility of profit manipulation. AQI is an asset quality index. If this index, which is the sum of current assets and property, plant and equipment to total assets, is greater than 1, the company has increased deferred costs and intangible assets, and consequently, the possibility of profit manipulation increases. SGI is an indicator of sales growth and does not indicate profit manipulation alone, but there is a possibility of profit manipulation with increased sales compared to the previous period.

DEPI is the depreciation expense index, and if it is greater than 1, it indicates that the company has increased the estimates of property, plant and equipment and the possibility of manipulation increases. SGAI is the general and administrative expenses and the selling index. If this index is greater than one, it is a negative sign of the company's future prospects, and there is a possibility of profit manipulation. TATA is the accruals index and is the ratio of accruals to total assets. If this index increases, the possibility of profit manipulation increases. LVGI is the financial leverage index and the ratio of the sum of long-term and current liabilities to total assets. If this index increases, it indicates an increase in the possibility of profit manipulation. The Beneish Model is defined by the following financial ratios:

$$DSRI = \frac{Receivables_t/Sales_t}{Receivables_{t-1}/Sales_{t-1}}$$

$$GMO = \frac{\text{Gross Margin}_{t-1}/Sales_{t-1}}{\text{Gross Margin}_t/Sales_t}$$

$$AQI = \frac{\text{Non-Current Assets}_t/\text{Total Assets}_t}{\text{Non-Current Assets}_{t-1}/\text{Total Assets}_{t-1}}$$

$$SGI = \frac{Sales_t}{Sales_{t-1}}$$

$$DEPI = \frac{Depreciation_{t-1}/PPE_{t-1}}{Depreciation_t/PPE_t}$$

$$SGAI = \frac{\text{SG\&A Expenses}_t/Sales_t}{\text{SG\&A Expenses}_{t-1}/Sales_{t-1}}$$

$$LVGI = \frac{\text{Total Debt}_t/\text{Total Assets}_t}{\text{Total Debt}_{t-1}/\text{Total Assets}_{t-1}}$$

$$TATA = \frac{\text{Net Income}_t - \text{Cash Flow from Operations}_t}{textTotalAssets_t}$$

2.3 Bayesian networks

Bayesian networks are graphical probabilistic models that represent a set of random variables for a given problem and the possible relationships between them. The structure of a Bayesian network is represented by a graph in which each variable is represented by a node and arrows indicate the relationships between variables. The probabilistic part of a Bayesian network is represented by a set of conditional probabilities [24]. The most important feature of a Bayesian network is its ability to encode both qualitative and quantitative information. Bayesian networks do not require complete observational data, which is important in forecasting studies because fraudulent samples and companies that manipulate financial statements and information are usually small and do not want to publish their full information. Bayesian networks are dynamic and easily adapt to new data. Compared to other methods,

such as neural networks, Bayesian network models are more transparent because they clearly show the relationships between variables through conditional probability plots. Based on the graphical structure, Bayesian network models include: simple Bayesian model, Bayesian decision tree model and general Bayesian model. Much research has been conducted over the last 10 years on various issues and problems that face uncertainty using expert systems and artificial intelligence. Bayesian networks are powerful tools for presenting images of relationships between a set of variables and dealing with uncertainty in expert systems. The basis of Bayesian networks is the Bayesian rule, which is expressed as follows:

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)},$$

where $P(A|B)$ is the probability of event A occurring given the existence of B [17]. The joint probability distribution of the Bayesian Network is:

$$P(X_1, X_2, ..., X_n) = \prod_{i=1}^{n} P(X_i|Pa(X_i)).$$

Hossein Alinejad et al. [12] investigated the application of particle swarm genetic algorithm and neural networks in predicting earnings manipulation. The samples included 150 companies listed on the Tehran Stock Exchange between 2015 and 2018, and the modified Jones model was used to measure earnings manipulation. The results of this study showed that neural networks have the greatest ability to predict earnings management. Also, according to the results, the accuracy of the combined model of genetic algorithm, particle swarm and neural networks for predicting earnings management is higher than the combined model of genetic algorithm with neural networks. Izadpour et al. [10] examined the relationship between operating cash flow manipulation and auditor's opinions with the moderating role of internal control and the first-tier auditor. Their sample was 130 companies listed on the Tehran Stock Exchange, and their research was applied in terms of purpose, quantitative and post-event data, and descriptive-correlational in terms of analysis. Their results showed that companies that manipulate their operating cash flow more often receive modified audit reports. Also, the presence of first-tier auditor institutions strengthens the relationship between operating cash flow manipulation and the auditor's report, but internal controls do not affect this relationship.

Pourghadimi et al. [21] presented an extended model of the Benish model with an emphasis on the specific characteristics of the company using neural networks, vector machines and random forests models. In this study, the Benish model was extended based on the specific characteristics of the companies, which were the ratio of cash flow, stock price to cash flow, dividend ratio and competition in the product market. The fitting of the vector machine model and the random forest, and the neural network was used to fit the extended model. The results showed that the accuracy of the coefficients of the random forest model was 99 percent and higher than the two neural networks and vector machine models, which were 94 percent, and the accuracy of the extended model was higher. Also, the results showed that the characteristics of the company are effective in predicting fraud in financial statements and should be considered by capital market participants. The findings of this study are effective in improving the prediction of fraud in financial statements and also draw the attention of users to the combination of financial statement information and auditor report characteristics in predicting fraud.

Malekinia et al. [18] developed a model for predicting earnings manipulation using a combination of neural networks and cosmological algorithms. In this study, a model based on the Benish model was presented with an emphasis on governance variables, including the structure of the audit committee, the inspector and independent auditor, the ownership structure, and the structure of the board of directors, which attempted to increase the accuracy of predicting earnings manipulation. The samples included 81 companies listed on the Tehran Stock Exchange between 2012 and 2018. Artificial neural network models and cosmological algorithms were used for the analyses. The results showed that the combination of neural networks with cosmological algorithms increased the accuracy of predicting earnings manipulation detection models.

Marais et al. [19] compared the Benish and Dicho models for predicting financial statement fraud in South Africa. The study examined and compared the ability of the Benish and Dicho models. The study also examined the similarities in earnings management characteristics between fraudulent and non-fraudulent firms. Finally, the study re-estimated the coefficients of the models based on current South African data to determine whether this improves their predictive abilities or not. The samples included 23 companies with financial statement manipulation and 2,320 companies without manipulation over the period 2006 to 2018. The results of estimating the sensitivity coefficients of the Benish model scores reduced by an average of 52.6%, but improved the accuracy by an average of 21.4%. Conversely, estimating the sensitivity of the Dicho score increased by an average of 58% but increased the type II error by an average of 48%. These findings suggest that either the Benish and Dicho models are not appropriate for South African financial statements or that they fail to identify manipulators correctly. Therefore, investors and other

stakeholders should exercise caution when using these models in South Africa.

Hyblova et al. [14] examined the manipulation of financial statements based on information published in corporate reports. They believe that financial reporting is a source of information that is used as a basis for economic decision-making and that its information is necessary for calculating financial indicators that serve to assess the financial health of a company. The aim of their study was to examine whether users of financial statements can trust the accuracy of information contained in financial statements published in the usual way in available sources. The research data were financial statement information of the top Czech-listed companies in the income category. They examined whether the reports showed any signs of accounting data manipulation using the pre-tax cash flow income method and a method aimed at confirming a linear relationship between pre-tax income and cash flow. The results yielded interesting findings, showing that accounting estimates are often influenced by the subjective decisions of financial statement preparers.

Erdogan and Erdogan [8] investigated the manipulation of financial statements using the Benish model. Their aim was to determine the financial companies that have manipulated financial information using the Benish model and then to determine the financial indicators of possible manipulation of financial statements using logistic regression. For this purpose, the companies listed on the Istanbul Stock Exchange were examined in the period from 2015 to 2017. After determining the companies that had the possibility of financial manipulation, it was determined by the Benish model that there is a positive relationship between the possibility of manipulation of financial information and the asset quality index and the general and administrative expenses index. Based on the principles presented above, the hypotheses of this study have been formulated as follows:

First Hypothesis: It is possible to predict financial statement manipulation using the Benish model in the Tehran Stock Exchange.

Second Hypothesis: It is possible to predict financial statement manipulation using Bayesian networks in the Tehran Stock Exchange.

Third Hypothesis: Bayesian networks perform better than the Benish model in predicting financial statement manipulation.

3 Research methodology

The present study is an applied research in terms of its implementation result and purpose, so that its results will lead to the identification and presentation of models for predicting financial statement manipulations and will determine the importance of correct reporting with correct information. From the perspective of the research implementation process, it is a quantitative and post-event research, and from the perspective of the research implementation logic, it is a research with a combined deductive-inductive approach, so that the research objectives were determined using the deductive approach and the research hypotheses were tested using the inductive approach. In terms of analysis, this research is a descriptive-correlational research. The statistical population of the research was all companies listed on the Tehran Stock Exchange in the period 2018 to 2022. The samples were selected using a systematic exclusion method with restrictions. A total of 145 companies were selected as samples.

In this study, companies with distortions and manipulations were selected based on 1) an unqualified audit opinion with a qualified clause regarding distortions in financial data, 2) the existence of tax disputes with the tax jurisdiction according to the income tax reserve note and tax file and the qualified clause of the audit report, 3) the existence of significant annual adjustments and restated financial statements and the Benish model and Bayesian networks and their variables were calculated. In order to collect data in the theory and theoretical foundations section, the library method was used, and in order to collect the statistical data required for this study, the document mining method was used. Data analysis was performed using regression models and with the help of EViews and Jenny software.

4 Research findings

To test the research hypotheses, in order to estimate the coefficients of the model in this study, multivariate regression and the logistic method were used. Since in this hypothesis, the dependent variable (companies with financial statement manipulation and non-financial statement manipulation) was used in the form of conditional valuation (zero and one), therefore, the logit model was used to test this hypothesis and estimate the specified model. Unlike the linear probability model, the final effect of an explanatory variable in logit or probit models depends not only on the coefficient of that variable, but also on the values of all explanatory variables in that model, so that the conditional

probability of the success state is achieved. The fit of the logit model according to the Benish model is presented in Table 1 as follows. It should be noted that, based on the aforementioned theoretical foundations, companies with a coefficient related to the dichotomous variable (1 for companies that are likely to manipulate financial statements and 0 for companies that are not likely to manipulate financial statements) are defined and the number one (zero) is used in the model.

Table 1: Results of fitting the M-score model

Variable	**Symbol**	**Coefficient**	**Standard Deviation**	**Z-Statistic**	**Probability**
Width from origin	C	-8.544	1.841	-4.640	0.000
Sales index	DSRI	3.459	0.597	5.790	0.000
Margin of safety index	GMI	1.994	0.418	4.775	0.000
Asset quality index	AQI	1.279	0.299	4.279	0.000
Sales growth index	SGI	2.897	0.643	4.509	0.000
Depreciation index	DEPI	0.421	0.124	3.402	0.001
SG&A index	SGAI	-0.868	0.187	-4.643	0.000
Revenue index	ATA	18.531	3.216	5.763	0.000
Leverage index	LVGI	-2.203	0.584	-3.775	0.000
Maximum accuracy statistic= 708.9			LR statistic error level= 0.000		
Log-likelihood= -221.056					

Table 1 shows the results of the logit model according to logistic regression. The most important statistics used to evaluate the goodness of fit of the fitted model are the maximum likelihood statistic (LR), the associated error level, and the value of the Log-likelihood statistic obtained from using the model. The maximum likelihood statistic is 9.708 with an error level of zero, which indicates the rejection of the hypothesis H0 (the chance of the model being insignificant) and the confirmation of the significance of the model and its reliability. Also, another criterion used for evaluation is the value of the Log-likelihood statistic, where the negative value of the statistic and the larger its absolute value indicate the suitability of the model. The value obtained for this model is -221.056, which is also based on this; the model is meaningful and reliable.

According to the information obtained, to estimate the occurrence or non-occurrence of the desired event, the logistic distribution probability statistic is used, in which the probability relationship (4.1) is used to determine the manipulation of financial statements.

$$P_i = 1/(1 + e^{-z_i}), \qquad Z_i = BX + u_i. \tag{4.1}$$

It is necessary to clarify that if the probability of occurrence is predicted to be more than 0.5, then the financial statements are considered to be manipulated, otherwise, the financial statements are considered not to be manipulated. Another method used to check the efficiency of the model is to check the correct percentage of probabilities predicted by the fitted model. For this purpose, these probabilities are compared with a threshold, which is a number between zero and one and is usually taken to be 0.5. For values of one, the higher the percentage of correctly predicted probabilities, the more accurate the prediction and, consequently, the more efficient the model will be. Correct classification is achieved when, if there is a value of zero for the dependent variable, the predicted probability value is less than or equal to the threshold, and if there is a value of one for the dependent variable, the predicted probability value is greater than the threshold.

The results show that out of a total of 868 observations according to the logistic model (fitted in Table 1), 237 observations indicated financial statement manipulation and 631 indicated no financial statement manipulation. Based on the results, the percentage of accurate predictions of companies with no earnings manipulation and companies with earnings manipulation is 38.83 percent and 95.36 percent, respectively, which indicates that the model was able to correctly predict 38.83 percent of companies that did not manipulate earnings and 95.36 percent of companies that manipulated earnings. Therefore, in a general review, it can be stated that the overall separation rate of the model in detecting manipulation or non-manipulation of earnings is 84.26%. In a general analysis of the results of the prediction method in the logistic regression model, it shows that, considering the probability percentage being higher than 50%, it can be concluded that the M-score Benish model has the ability to predict manipulation of financial statements among companies listed on the Tehran Stock Exchange, and the first hypothesis of the research is confirmed.

As stated, the second hypothesis aims to determine the ability to predict financial statement manipulation using the Bayesian model in listed companies. The selection of variables in the simple Bayesian network method is based on conditional correlation. The heuristic method used in this study to select variables is based on conditional correlation between variables. In this method, first, the correlation between all variables, the manipulation variable and all predictor variables is obtained. In this method, according to the significance level of the Pearson correlation coefficient,

the variables that have a significant correlation with the manipulation variable have an effect on the manipulation variable and were selected as the first layer of the simple Bayesian network. Figure 1 shows the variables of the first layer of the simple Bayesian network that were selected with this method. The probability of each node is determined according to the information of each company and assigned to the corresponding node, and after determining the probability of all nodes, inference is performed, and the probability of manipulation of a company's financial statements is calculated.

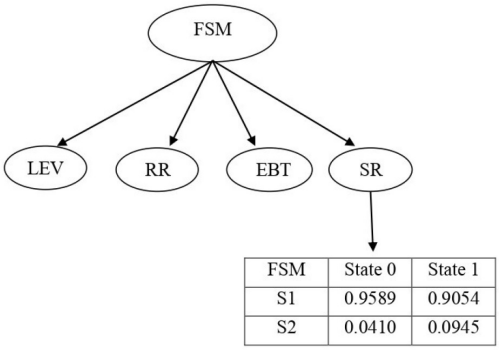

Figure 1: First layer of simple Bayesian network

- **LEV:** Financial leverage ratio equals the ratio of liabilities to total assets
- **RR:** Accounts receivable ratio equals the ratio of total accounts receivable to total sales
- **EBT:** Ratio of earnings before taxes to total assets
- **SR:** Sales ratio equals this year's sales minus last year's sales divided by last year's sales

Then, in the second step, to select the second layer of the Bayesian network, the second layer variables that have an effect on the first layer variables are selected. The conditional correlation between the variables and the manipulation variable is calculated provided that the first layer variables exist, and thus a simple Bayesian network is constructed. Considering the relationship between the first layer variables and the second layer of the simple Bayesian network, it is observed that most of the variables that were in the same group are related to each other.

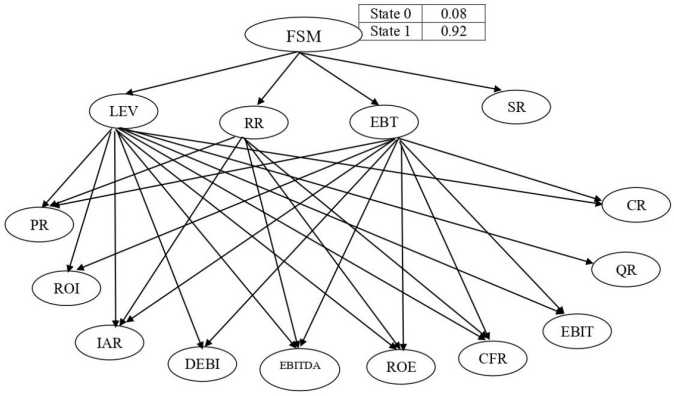

Figure 2: First layer of simple Bayesian network

- **PR:** Accounts payable ratio to total assets
- **ROI:** Return on investment ratio
- **IAR:** Intangible assets ratio to total assets
- **DEBI:** Long-term debt ratio to total debt

- **EBITDA:** Earnings before interest, taxes, depreciation and amortization to total assets
- **ROE:** Earnings to equity ratio
- **CFR:** Operating cash flow to total assets
- **EBIT:** Earnings before interest, taxes, depreciation and amortization to total assets
- **QR:** Current ratio equals current assets minus inventories and prepayments divided by current liabilities
- **CR:** Current ratio equals current assets to current liabilities

In general, this model was able to accurately predict 90% of companies with financial statement manipulation and 89% of companies without financial statement manipulation. Thus, the overall accuracy of the model is 90% and the model error is 10%. Given the high accuracy of this model, the second hypothesis of the research is accepted and it is concluded that this model has the ability to predict financial statement manipulation of companies listed on the Tehran Stock Exchange. As stated, the third hypothesis of this study aims to compare the performance of predicting financial statement manipulation using the Bayesian and Benish models in companies listed on the Tehran Stock Exchange. According to the estimation results of the Bayesian model, this model had a power of 90% to predict companies that had manipulated financial statements, and the Benish model had a power of 84.26% to predict financial statement manipulation among companies listed on the Tehran Stock Exchange.

Therefore, it is concluded that the Bayesian model has a greater ability to predict financial statement manipulation than the Benish model, and the third hypothesis is accepted.

5 Discussion and conclusion

According to the first hypothesis of the study, it is possible to predict financial statement manipulation using the Benish model in the Tehran Stock Exchange. The results of testing this hypothesis showed that this model has the ability to predict financial statement manipulations with 84.26% accuracy, and therefore, the first hypothesis of the study was accepted. According to the Benish model, which is a linear model for detecting financial information manipulations, indicators such as changes in receivables to sales changes, gross profit margin, asset quality, sales growth, depreciation expense, general and administrative expenses and sales, accruals index, and financial leverage can predict information manipulation in companies listed on the Tehran Stock Exchange.

The results of the first hypothesis test confirm that these indicators are among the most important issues that users of corporate financial information should pay special attention to when making their decisions. The results of the test of this hypothesis are consistent with the results of the research of Pourghadimi et al. [21] and Rahimian and Haji Heydari [23], but they are not consistent with the results of Marais et al. [19] because in their research, the Benish model was not able to predict the manipulation of financial statements among African companies. According to the second hypothesis of the study, it is possible to predict financial statement manipulation using Bayesian networks in the Tehran Stock Exchange. The results of testing this hypothesis showed that this model has the ability to predict financial statement manipulations with 90% accuracy, and therefore, the second hypothesis of the study was accepted. According to the Bayesian model, which is an artificial intelligence model for detecting financial information manipulations, indicators such as sales ratio, intangible asset ratio, operating cash flow ratio, current ratio, current ratio, profitability indicators, accounts payable ratio, accounts receivable ratio, return on investment, financial leverage, debt ratio, and equity ratio have the ability to predict information manipulation in companies listed on the Tehran Stock Exchange.

The results of the second hypothesis test confirm that these indicators are among the most important issues that users of corporate financial information should pay special attention to when making their decisions. According to the third hypothesis of the study, the performance of Bayesian networks is better than the Benish model for predicting financial statement manipulation. According to the results of the study, the performance of the Bayesian model with 90% accuracy was better than the performance of the Benish model with 84.26% accuracy, and therefore, the third hypothesis of the study was accepted. According to the research results, linear models such as the Benish model focus on analyzing financial ratios and financial statement figures, which, despite good predictive power, have been criticized for their high correlation between financial ratios and failure to identify nonlinear relationships. Artificial intelligence models such as Bayesian networks are often nonparametric, and in applying these models, there is little need for initial assumptions and information about how financial characteristics are distributed among groups of manipulated and unmanipulated companies.

In fraud and financial statement manipulation detection research, there are always two types of errors that can occur: Type I error occurs when the model incorrectly classifies a company with financial statement manipulation as healthy. Type II error occurs when the model incorrectly classifies a healthy company as a company with financial statement manipulation. According to Altman [3], artificial intelligence methods and models performed best in predicting and detecting financial statement fraud, with a type I error of 5 percent and a type II error of zero. However, in this study, only one artificial intelligence method, Bayesian networks, was examined, and the results showed that the performance of this model was better than the linear Benish model. In the process of conducting any research, there are limitations that are beyond the control of the researcher, but can potentially affect or cause problems with the research results. Some of the most important limitations of this research are:

- Given that the data have not been adjusted for inflation and price level changes, the results may be different if the data is adjusted for inflation.
- Given the time frame considered in the research, generalization of the results to other time periods should be done with caution.
- Generalization of the results to industries that have been excluded from the statistical sample should be done with caution.

According to the results obtained from testing the research hypotheses in companies listed on the Tehran Stock Exchange, it can be suggested to auditors, including certified public accountants and internal auditors, the government and relevant government institutions, investors, analysts, and other users of financial information, to use the Benish and Bayesian models to predict the manipulation of companies' financial information and identify companies with manipulated information, and in this way, they can make more correct decisions. In regard to the results obtained and the limitations of this study, researchers are advised to investigate the following in the future:

- Investigating the possibility of detecting financial statement manipulation in companies listed on the Tehran Stock Exchange using other methods such as decision trees, data mining, or AdaBoost models.
- Investigating the impact of predicting financial statement manipulation on the decision-making of managers, analysts, and investors.

References

[1] S.O. Act, *Sarbanes-oxley act*, https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=1e106d64c637d9c4c3860d6cbde5db7392689d94, Washington DC, 2002.

[2] K. Alden, J. Timmis, P.S. Andrews, H. Veiga-Fernandes, and M.C. Coles, *Pairing experimentation and computational modeling to understand the role of tissue inducer cells in the development of lymphoid organs*, Front. Immunol. **3** (2012), 172.

[3] E.I. Altman, *Predicting financial distress of companies: revisiting the Z-score and ZETA® models*, In Handbook of research methods and applications in empirical finance, Edward Elgar Publishing, 2013, pp. 428–456.

[4] C.S. Armstrong, W.R. Guay, and J.P. Weber, *The role of information and financial reporting in corporate governance and debt contracting*, J. Account. Econ. **50** (2009), no. 2–3, 179–234.

[5] M.D. Beneish, *The detection of earnings manipulation*, Financ. Anal. J. **55** (1999), no. 5, 24–36.

[6] N. Burns and S. Kedia, *The impact of performance-based compensation on misreporting*, J. Financ. Econ. **79** (2006), no. 1, 35–67.

[7] A. Daghmechi Firouzjaei, *Accountability in financial reporting: detecting fraudulent companies*, Master's Thesis, University of Mazandaran, 2015. [In Persian]

[8] M. Erdogan and E.O. Erdogan, *Financial statement manipulation: A Beneish model application*, S. Grima, E. Boztepe and P.J. Baldacchino (Eds.), Contemporary issues in audit management and forensic accounting, Emerald Publishing Limited, 2020, pp. 173–188.

[9] E. Erikson and M. Hamilton, *Companies and the rise of economic thought: The institutional foundations of early economics in England, 1550–1720*, Amer. J. Soc. **124** (2006), no. 1, 111–149.

[10] M. Ezadpour, A.M. Kordi, F. Tavousi, and Z. Heydari Sureshjani, *Operating cash flow manipulation and auditor's opinion: The moderator role of internal control and audit first ranking*, Judg. Decision Mak. Account. and Audit. **2** (2013), no. 7, 1–24. [In Persian]

[11] K. Farghandoust Haghighi, S.A. Hashemi, and A. Foroughi Dehkordi, *Study of the relationship between earnings management and the possibility of fraud in the financial statements of companies listed on the Tehran Stock Exchange*, Audit. Knowledge J. **14** (2013), no. 56, 47–68.

[12] M. Hoseinalinezhad, S.M.H. Hashemi Kucheksarai, and A. Jafari, *Application of genetic algorithm, particle swarm and artificial neural networks in predicting profit manipulation*, J. Invest. Knowledge **13** (2024), no. 52, 613–630. [In Persian]

[13] M.A. Howe, *Management fraud and earnings management: Fraud versus GAAP as a means to increase reported income*, Ph.D. Dissertation, University of Connecticut, 1999.

[14] E. Hyblova, A. Kolcavova, T. Urbanek and Z. Petrakova, *Can information from publicly available sources reveal manipulation of financial statements? case study of Czech and Slovak companies*, Sci. Papers Univ. Pardubice. Ser. D, Faculty Econ. Admin. **30** (2022), no. 3.

[15] S. Khajavi and M. Ebrahimi, *Investigating the effect of corporate governance mechanisms on fraud in financial statements of companies listed on the Tehran Stock Exchange*, J. Asset Manag. Financ. **6** (2018), no. 2, 71–84. [In Persian]

[16] I. Kononenko, *Comparison of inductive and naive Bayesian learning approaches to automatic knowledge acquisition*, Current Trends Knowledge Acquis. **8** (1990).

[17] G. Koop, D.J. Poirier, and J. Tobias, *Semiparametric Bayesian inference in multiple equation models*, J. Appl. Econ. **20** (2005), no. 6, 723–747.

[18] N. Malekinia, R. Tehrani, A. Alam Tabriz, and M. Fallah Shams, *Development of a profit manipulation prediction model using a hybrid neural network and cosmological algorithms*, Monetary Econ. **28** (2021), no. 21, 57–86. [In Persian]

[19] A. Marais, C. Vermaak, and P. Shewell, *Predicting financial statement manipulation in South Africa: A comparison of the Beneish and Dechow models*, Cogent. Econ. Financ. **11** (2023), no. 1, 2190215.

[20] J.L. Perols and B.A. Lougee, *The relation between earnings management and financial statement fraud*, Adv. Account. **27** (2011), no. 1, 39–53.

[21] K. Pourghadimi, J. Bahri Sales, S. Jabarzadeh Kangarluei, and A. Zavari Rezaei, *Presenting an extended model of the Benish model with emphasis on audit quality characteristics using neural networks, vector machines and random forests*, Adv. Finance Invest. **3** (2013), no. 6, 1–30. [In Persian]

[22] N. Rahimian, *Practical Guide to Managing Fraud Risk in Business*, First Edition, Itila'at Publications, 2010. [In Persian]

[23] N. Rahimian and R. Haji Heydari, *Fraud detection using the modified Benish model and financial ratios*, Empir. Res. Account. **8** (2019), no. 31, 47–69.

[24] L. Sun and P. Shenoy, *Using Bayesian networks for bankruptcy prediction*, Eur. J. Oper. Res. **180** (2007), no. 2, 738–753.